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SEVENTH ANNUAL REPORT

OF THE

NORTH DAKOTA

Agricultural Experiment Station

FARGO, N. DAK.

TO THE GOVERNOR.

FEBRUARY 1st, 1897.

FARGO, N. D.:
ARGUS, STATE PRINTERS AND BINDERS,
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LETTER OF TRANSMITTAL.

FARGO, N. D., Feb. 1, 1897.

To His Excellency FRANK A. BRIGGS,

Governor of the State of North Dakota:

SIR: As required by the act of congress, approved March 2, 1887, Section 13, Chapter 160 of the Laws of 1890, for North Dakota, I hereby submit the Seventh Annual Report of the North Dakota Agricultural Experiment Station for the year ending February 1, 1897, together with a financial statement of receipts and disbursements, as required by law, for the government fiscal year ending June 30, 1896.

Very respectfully yours,

W. H. ROBINSON,

President of the Board of Trustees.

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REPORT.

To the Board of Trustees of the North Dakota Agricultural College and Experiment Station.

GENTLEMEN: I have the honor to submit to you the Seventh Annual report of the Agricultural Experiment Station.

The heads of the different departments have embodied in their reports to me such experiments and original investigations as fairly indicate the lines of work they have severally pursued, but more particularly such matter as will be of interest to the farmer and stockman.

These reports contain many separate items, not suitable for the bulletin publications, owing to their brevity, but of value to agriculture nevertheless, and are given a place in this general report as required by law.

I desire to call special attention to the experiments made by the Department of Agriculture with cereals and vegetables adapted to this climate.

CHEMICAL DEPARTMENT.

To Director J. H. Worst:

During the past year the work of soil analysis has been continued and bulletin No. 24 prepared and published detailing the result of the analysis. The reader is referred to this bulletin for information on the subject of soils so far as results have been published. A further study of the chemistry of the soils of North Dakota will be continued, also as to their geological formation with reference to fitness for such crops as sugar beets, barley, sorghum and legumes and the relation of soil humus to fertility and soil exhaustion of nitrogen.

During the past year a line of food investigation and dietary studies has been made under direction of Dr. Atwater, for the Department of Agriculture at Washington. The results of this are expected to be issued from Washington in bulletin form.

A large number of artesian and well waters have been sent in for analysis during the year, and considerable time has been devoted to this work. This line of analysis, though generally not considered true experimental work, is of special importance in this state for two reasons:

First. As to the adaptability of the artesian waters for irrigation purposes.

Second. To determine whether the well waters in parts of the state where alkalies are abundant contain enough of such salts to be detrimental to stock when drunk in ordinary quantities. A few of the results have been appended to this report.

The Chemical Department is now engaged in a study of the proximate organic constituents of millet to find what active principle it contains that may be a possible cause of such marked disturbances as seem to follow the feeding of millet to horses.

As in the past, the work of meteorology has been carried on by this department and regular reports furnished the State Weather Bureau.

SOIL MOISTURE.

Determinations have been made each week from April to October inclusive, of the per cent of moisture contained in the soil of the Agricultural College campus.

The surface soil to a depth of three inches, and also at a depth of five to seven inches.

MONTH.	Surface Soil 1 to 3 in.					Subsoil 5 to 7 in.				
	1892	1893	1894	1895	1896	1892	1893	1894	1895	1896
April	39.17	....	34.31	28.49	....	32.83	....	30.88	26.23	.....
May	35.08	31.48	29.15	23.98	31.43	35.51	30.21	26.98	24.99	27.77
June	29.08	22.63	16.73	22.56	22.03	30.23	23.79	19.84	22.43	23.37
July	28.39	28.63	16.09	22.97	11.89	27.19	26.97	18.58	21.39	13.65
August	30.08	21.46	16.49	15.21	15.86	30.53	21.57	16.52	16.81	17.39
September	28.94	18.88	11.11	20.74	28.34	27.94	19.71	11.89	17.32	24.03
October	14.08	24.59	28 30	17.44	12.55	19.87	24.01	24.78	15.75	11.77

An inspection of the above table shows considerable variation in per cent of moisture for different months, and a notable point is the exceptionally low per cent in the ground in the falls of '95 and '96 as compared with the two preceding years.

CAMPBELL'S METHOD OF SOIL CULTURE.

Considerable attention has been attracted to the Campbell method of soil culture during the past year, and any information bearing on this subject will be of interest to the farmers of the state.

August 29th a visit was made to the experimental fields at the Soldiers' Home at Lisbon, where Col. McIlvaine was conducting an experiment in wheat growing by this method. At this date the crop from both fields had been harvested, but as our object was to determine the amount of moisture in the soil, samples of soil were taken from each field and the results are shown in the following table:

	METHOD OF CULTURE.	
	Campbell.	Ordinary.
Surface soil	18.30	20.80
Soil 8 to 12 inches	16.90	14.30
Soil 14 to 18 inches	16.90	.....

Recent rains may have affected the surface soil moisture. It should be borne in mind that there was no crop upon the land at the time.

Samples of soil were also taken from fields similarly treated at Glen Ullin, in the semi-arid belt of the state, and the results are shown below.

	METHOD OF CULTURE.	
	Campbell.	Ordinary.
Surface soil	9.34	9.02
Soil 12 to 14 inches deep	7.19	4.08
Soil 18 to 20 inches deep	6.62	6.30

While it is not our purpose to present any conclusions from the above figures, yet with the conditions existing in this state it would seem advisable to continue experiments along this line to determine what conditions of culture are most economical and favorable to properly conserving the soil moisture.

CONSERVING SOIL MOISTURE.

In 1895 an experiment was undertaken for the purpose of determining the influence of the different methods of Soil Culture Cultivation on conserving the soil moisture for periods of drought.

Five plots of ground in the experiment fields were selected and

each subjected to a different method of treatment, but crops were not allowed to grow upon any of them. The land had all received the same previous treatment.

Plot I. This was kept free from growing weeds, but otherwise not disturbed.

Plot II. The surface was cultivated to a depth of one inch each four days.

Plot III. The surface of this plot was cultivated to a depth of three or four inches each four days.

Plot IV. The ground was rolled and then the surface stirred to a depth of one inch each four days.

Plot V. This plot was mulched with dry straw manure, and weeds not permitted to grow.

The experiment was not begun until July 1st, and was continued until September 30th. The following table shows the per cent of moisture for the dates given for surface one to two inches deep, also for a depth of five to seven inches.

On September 30th the depth is for two feet, to see what difference there might be at this point, and August 7th at a depth of one foot.

Dates of Samples.	PLOT I.		PLOT II.		PLOT III.		PLOT IV.		PLOT V.	
	1 to 2 in	5 to 7 in	1 to 2 in	5 to 7 in	1 to 2 in	5 to 7 in	1 to 2 in	5 to 7 in	1 to 2 in	5 to 7 in
July 1	22.18	28.02	22.18	28.02	22.18	28.02	22.18	28.02	22.18	28.02
July 13	23.39	28.00	25.52	26.80	25.53	29.48	27.37	30.00	32.03	31.02
July 27	27.81	26.55	28.14	26.92	26.50	32.02	29.13	29.54	31.46	35.54
August 3	19.73	29.33	24.53	27.92	24.19	29.48	28.36	27.02	32.14	32.57
August 11	.....	25.70	.....	25.62	.....	28.70	.....	27 35	.....	32.24
August 17	20.38	26.51	28.43	27.84	25 77	29.38	23.89	18.22	31.71	38.84
August 24	2 .97	26.17	24.37	27.67	22.56	24.75	25.25	29.71	35.74	29.61
August 31	24.12	?	27.63	27.61	25.78	33.18	27.31	28.93	36.74	31.50
September 7	26.66	28.45	25.23	28.24	27.39	29.48	25.75	27.35	33.05	32.62
September 14	24.63	29.26	25.00	28.00	28.20	28.88	24.05	27.83	32.32	32.30
September 30—2 feet	26	38	23	53	24	00	23	14	25	17
August 7—1 foot	15	73	26	69	27	00	25	33	26	60

Some of the results in the above table are not easily explained, and continued experiments are needed before any relation can be pointed out, and a more extended study made in relation to the daily rainfall.

TEMPERATURE AND RAINFALL.

The following table gives the maxima, minima and mean temperature for each month above the rainfall in inches.

	Maxima.	Minima.	Mean.	Rainfall Inches.
January	43	—29	4.3	.19
February	58	—19	10.6	.06
March	49	—30	12.4	X48
April	77	13	42.0	3.64
May	—	—	63.2	4.70
June	—	—	70.9	2.71
July	95	40	67.7	.91
August	94	32	65.2	2.17
September	94	28	53.8	2.58
October	79	—	41.4	1.96
November	33	—32	8.6	.70
December	41	—33	12 6	.26
Total				20.36

For two months owing to an accident the station was without maximum and minimum thermometers and no record can be presented for May and June.

The total rainfall for previous years has been in inches:

	1892.	1893.	1894.	1895.	1896.
Total rainfall	21.03	16.16	18.72	14.29	20.36

From the above it will be observed that the rainfall for 1896 was considerable more than for any previous year since 1892, which was in excess of the past year.

SMUT IN WHEAT.

During the past year considerable work has been done on wheat, and a special study made of wheat containing smut.

Without at this time presenting details, we may briefly summarize the results as follows:

1. The experiments indicated that when smut once finds its way into the berry, the entire kernel is destroyed and no starch is formed.
2. After the berry has developed in the wheat head, the smut does not seem to enter that berry. At least we have not found such a case in fully a thousand examinations.
3. If all the smut balls and adhering particles of smut are removed from the wheat, as good flour can be produced as from the same grade of wheat free from smut.
4. To remove the smut requires much additional expense at the mill, as well as special facilities.
5. The berries of wheat in a field affected with smut will not average as large and well developed as the berries from a field under like conditions, but free from smut. That is, the berries in a field of wheat free from smut averaged 5.16 per cent heavier than the berries in a field containing about 15 per cent of smut.
6. As the berries in each case were selected smut free, it is suggested that the difference in development may be due to the presence of smut in the stalk and not in the berry, thus preventing normal growth.
7. Flour containing but a very small per cent of smut is much injured in quality for bread-making, and in some way the gluten seems to be affected.
8. Therefore the loss in wheat is not only in the grain actually smutted, but in a smaller average development of berries for the whole field, resulting in a diminished yield and lower grade.

ARTESIAN WELL WATERS.

A large number of artesian waters have been sent in for examination, and the results of the analysis for a few of the samples are given, as showing the character of the water from different localities. The first is from a shallow artesian well less than 200 feet deep, while the others are for deep wells, above 1,000 feet.

PARTS PER MILLION.

	Abercrombie.	Hillsboro.	Jamestown.	Devils Lake.	Edgeley.
Total solids	1016	2900	2315	3476	5182
Chlorine	93	8 8	229	810	280

ANALYSIS OF SOLIDS.

	Abercrombie.	Hillsboro.	Jamestown.	Devils Lake.	Edgeley.
Organic matter, etc.....	5.47	2.38	2.23	00	2.38
Sodium oxide Na^2O.....	38.67	39.02	40.80	42.18	39.02
Potassium oxide K^2O.....	1.89	1.20	1.05	7.68	1.20
Magnesium oxide MgO.....	Trace	2.05	1.19	Trace	2.05
Calcium oxide CaO.....	4.64	6.05	7.04	0.80	6.05
Sulphuric acid SO^3.....	18.76	12.91	40.09	23.96	12.01

In several instances waters have been sent in for examination to know whether they contained any ingredient that might be the cause of colic in horses. Take for instance the Jamestown water mentioned above, which contains only half as much solids as many of the artesian waters. A horse drinking nine gallons of this water per day would take more than three ounces of various salts, more than one-half of which would be Glauber salts or sodium sulphate. With this amount of salts per day it would not be strange to have periodic attacks of colic.

E. F. LADD.

VETERINARY DEPARTMENT.

To Director J. H. Worst:

The Veterinary Department has completed the line of investigation with regard to the feeding of millet to horses, and published the results in Bulletin No. 26. The Department has also instituted a series of experiments to determine the influence of tuberculin upon the flow of milk when used as a diagnostic agent, for the purpose of determining the presence of tuberculosis in cattle. The injections of tuberculin were made regularly every month during the past year, and for that purpose fourteen animals were selected, seven of which were injected with tuberculin, and seven of which were not. Careful and accurate accounts were kept of the amount of milk produced by each animal with the percentage of butter fat. These experiments have not yet been tabulated, but will appear in a bulletin during the coming year.

During the year two animals of the college herd affected with tuberculosis were destroyed. One of them a steer nearly two years old, which showed marked lesions of the disease in the intestinal tract, which were very similar to those which were found in the dam of this steer, which was destroyed in July, 1894. The other animal, a pure bred Hereford, which had contracted the disease in some manner. Both were diagnosed by the use of tuberculin.

POULTRY DEPARTMENT.

In December, 1895, the Station also added a Poultry Department to those which already existed. It has been the endeavor of the manager to build this Department up gradually, and to make a careful and accurate account of the different forms of experiments which have been mapped out. We began our work with pure bred barred Plymouth Rocks, and pure bred Rose Comb Brown Leghorns. From time to time these breeds will be added to. During the spring of 1896, owing to the damp weather, eggs did not hatch satisfactorily, and the increase in our flock fell much below that which we desired.

We now have three good breeding pens of Plymouth Rocks, and one good breeding pen of Rose Comb Leghorns, so that the coming season we will be in position to carry out our line of experiments more fully than heretofore.

We caponized thirty-one cockerels, and at the last weighing, when they were twenty-two weeks old they averaged seven and one-half pounds each, while the young cockerels of the same age averaged but six pounds, although the feed was the same.

Jan. 1, 1896, we began a series of experiments to determine if possible, what effect, if any, heating the poultry house would have upon the production of eggs, and the food requirements.

On December 1st, we put forty-six chickens, including several varieties of birds into the poultry house. The weather at that time was quite warm and they were fed per day five pounds of feed in the morning and two pounds in the evening, the morning feed being table scraps such as meat, pieces of bread, boiled and fried potatoes, and such material as usually comes from a boarding table. Their ration of grain consisted of wheat screenings which was composed principally of small berries of wheat and cracked wheat. As the weather got colder, their feed gradually increased until they took on the 31st day of December eleven and three-fourths pounds of scraps in the morning, and eleven and a half pounds of wheat in the evening. During the month of January the feed ration remained about the same. January 20th a large stove was put into the house, and a fire started with lignite coal. On the 31st of January the feed had decreased to six pounds in the morning and eight and three-fourths in the evening. The last of March four and a half pounds mornings and four and three-fourths evenings.

The total amount of fuel burned from the 20th of January to the first of April cost $4.50. During the month of January previous to the use of the stove, the average number of eggs per day was 2¾, the remainder of the month from the 21st to the end of the month, it was 6 3-11, showing the influence that heat exerted upon the production of eggs.

The question naturally arises, can the farmer, under the conditions existing on the ordinary farm, afford to take care of his poultry by furnishing artificial heat? An examination of the above figures shows that but half the food is consumed, and that the egg production is more than doubled. With eggs worth twenty-five cents, per dozen at this season of the year and food at the ordinary prices, it should seem to me that it would not only be economy to heat the poultry house but would be a source of great profit, especially after arrangements had once been completed, so that it would require but little extra work.

Feeding for Eggs: That food has as much to do with the production of eggs, as it has with beef or butter, there is but little question. We placed two pens of fowls, under exactly the same condition as far as the temperature, room, and care were concerned but fed them with an entirely different object in view. One pen we wished for breeding purposes and did not want them to lay until the breeding season opened, so that we could get a more steady egg production than if they were made to lay during the entire winter. The other pen it was not intended to use at all for breeders, but to produce the greatest number of eggs possible, at the time of year when they would bring the highest price. During the month of December, 1895, the pen which was intended for lay-

ing experiment, contained nineteen pullets, and the one intended for breeding purposes contained sixteen pullets. During this month the laying pen laid sixty-three eggs, the non-laying pen no eggs. During the month of January the laying pen one hundred and twenty-four eggs. The non-laying pen seven eggs. During the month of February, the laying pen one hundred and nine eggs and the non-laying pen twelve eggs. During the month of March the laying pen one hundred and sixty-eight and the non-laying pen forty-three. During the month of April, the laying pen one hundred and twenty-nine, and the non-laying one hundred and eighty-nine.

We began the last of March to get our breeding pen, which has so far been designated as the "non-laying pen," into good laying trim, with the results as above stated. From this time on, the breeders, although less in number than the other pen, laid a great many more eggs. For the month of May, the laying pen laid one hundred forty-two eggs, the non-laying pen three hundred eighty-one eggs.

The method of feeding that was employed to bring this about was substantially as follows: The morning feed for those which were intended to produce eggs, consisted of boiled lean meat, scraps from the table, the fat having been removed, wheat screenings, with constant drinking water. For the evening feed, wheat screenings what they wanted to eat, mixed with corn twice per week. Those which were not intended for producing eggs were fed on wheat screening of poorer quality with corn. These gradually increased in weight until they had the appearance of being overfat. This pen, although not put to laying until the first of April, averaged one hundred fifty and a half eggs per hen during the season. They were pure bred Plymouth Rocks. The other pen which was put to laying during the entire winter averaged one hundred fifty-three eggs per hen. The average price of the eggs was eighteen cents per dozen. The average price of the former, or those which did not begin laying until April 1st was eleven and a half cents per dozen, at regular market prices. This shows a marked difference in the average price, due principally to the high price of eggs during the months of December, January, February and the fore part of March. T. D. HINEBAUCH.

DEPARTMENT OF HORTICULTURE AND FORESTRY.

To Director J. H. Worst:

In the vegetable garden, experiments in the cultivation of celery established the following points:

First. That the period of transplanting cannot safely be delayed after June 1st.

Second. That banking the celery when the soil is excessively dry, especially during warm weather, causes the celery to rot at the heart. To avoid both rust and rot, heavy banking should not begin until cold weather in September.

Third. The best distance apart for the rows is four feet. Under this system alternate rows should be banked and bleached, and then removed when the remaining rows are similarly handled.

Fourth. Celery for winter use, planted in boxes, cellars or pits, should have the roots pruned back to two inches in length and the bunches should also receive considerable top pruning, but the outer stalks should not be stripped off.

Fifth. White plume is the best variety so far for general culture.

Cauliflower culture not having been entirely successful during the previous years, a plan of experiments was instituted to test varieties and methods adapted to this section. The cut worms were so numerous as to resist all ordinary methods for their extermination, and the plants were all destroyed. Work with cabbages and onions suffered a like fate.

The department devotes considerable time to transplanting trees, especially evergreens, and to the culture of the arboretum and to the care of trees upon the grounds generally. Out of a total of over one thousand evergreens transplanted, ranging in height from five to ten feet, only three are dead.

The work in tree culture is reviewed in bulletin No. 25, now being distributed.

Much of the work of the department has been in the direction of improving the walks and drives so as to facilitate ease and comfort in travel upon the college grounds, especially during the muddy season.

Coal and wood ashes mixed form a hard surface, which makes a better walk than cinders, and nearly as good as gravel.

An excavation six inches deep, edged with boards and filled with the mixture well hammered down, makes a cheap and very passable walk. In the future this will make a good foundation for brick or cement.

THE ARMY WORM AND WHEAT FLY.

To Director J. H. Worst:

The attention of the Station has been directed during the season of 1896 to certain insect attacks. These consisted of ravages in the counties of Pembina and Walsh of the army worm *Lucania unipunctata*, and of a general attack upon the wheat fields of the state by a wheat fly which is either the Hessian Fly or the Frit Fly. Failure to obtain this insect in the adult stage has led to the uncertainty concerning the species that was responsible for the trouble, and authorities to whom the pupa stage has been submitted have disagreed as to its identity. This, however, is not a matter of great importance, since the treatment in either case would be the same. The army worm in the imago stage, is a brownish moth which lays its eggs in low lying meadows in early spring, or perhaps late in the fall. As those eggs hatch, the caterpillars begin feeding upon the adjoining vegetation, and when this is devoured, they begin marching in large numbers to the adjacent regions stripping the fields as they go. As found in Pembina county, they were just leaving the meadows, two or three hundred acres of which had been completely stripped by them, and were fast encroaching upon the adjoining grain fields. This was during the month of July. Their ravages were checked by plowing a furrow across their line of march, having the land side of the furrow on the opposite side from which the army worms were approaching. The army worms are unable to escape from a trap of this kind, and may be destroyed by dragging a stick of timber along the furrow, or by speading straw and burning, or by similar means.

If the meadows in which they lay their eggs are filled with a growth of dry grass at the bottom, it would be a good plan to burn the meadows, thus destroying the caterpillar before it attains any considerable size.

During the month of August, or about six weeks from the time of hatching, the caterpillar goes into the pupal or resting stage. This is a brown, hard case something over an inch in length, rounded at one end, and pointed at the other. The moth or adult form of the insect soon emerges from this case and lays its eggs to provide for the second brood. This hatches early in the fall, about the time that the wheat is ripening, and at this time the caterpillars are found feeding upon the heads of the wheat, or upon the leaves, if the wheat is yet green.

The caterpillar which is the destructive stage of this insect is

about one and a half inches long when full grown. Its under side is a greenish yellow, above this on each side is a dark lead colored stripe, above this a lighter colored stripe, and on the back a broad dark stripe which is divided in the middle by a fine white line interrupted at intervals of about an inch in length. The eyes are light brown in color and covered with a net work of dark brown lines. Its chief distinguishing marks are two lines starting at each side of the face approaching each other towards the top of the head where they run parallel for a short distance, and again diverge as they approach the back of the head. These markings are so characteristic that the insect cannot be well mistaken for any other species.

The moth is a sort of a brown or fawn color with wings extending slightly over an inch in breadth, each wing being marked with a light spot near the center. It is nocturnal in its habits and is rarely seen.

The wheat fly above mentioned has been noticed more or less through the state during previous seasons, but has never been so generally observed, or so abundant as in the season of '96. Its presence is detected by a breaking over of the wheat stalk at the second joint above the ground. On examining the wheat stalk at this place one will find one, two or three small brown bodies, somewhat resembling a flax seed. This is the pupal or resting stage of the insect. Earlier in the season one or more eggs were laid in this joint by a small fly, each egg hatched into a small white maggot which fed upon the wheat stalk causing the injury named.

It was found that a large number of insects emerged from this pupal stage during the month of September, but the flies were so small as to escape capture.

It is possible that these flies lay their eggs in the volunteer wheat, and that the species pass the winter either in the egg stage or in the "flax seed" stage found in the wheat at the time of ripening, passing the winter uninjured, and thus providing for the appearance of the adult insect the following spring.

By continued observation we hope to decide this point by another year. In any event it will be of obvious advantage to destroy the insect as soon as possible after the wheat is cut. This can be done by burning the stubble, or by early plowing. Unless these methods of extinction are universally practiced, but little good can come from them, since the insects that were allowed to survive in one region could easily infect all the adjoining regions. Enough of their life history is known to convince us of the necessity of burning or plowing under the stubble as soon after harvest as possible.

The chinch bug also appeared in two or three parts of the state, and instructions by letter were sent to the farmers in the infected regions.

The railroads generously co-operated in the matter of insect

extermination to the extent of furnishing transportation when necessary. As work in this line was not strictly experimental, and hence the Station funds are not available for the purpose, I would recommend that there be placed at the disposal of the college a small fund that could be used in emergencies that might arise, as railroad transportation is only a part of the expense.

For more efficient work along horticultural lines, including also tree culture, the department should be provided with grafting and storage rooms, where the necessary winter operations may be carried on, such as budding, grafting, and the preparation of cuttings, as well as the storing of bulbs and tuberous plants.

This should also be connected with a forcing house about 18 by 60, since the present small area under glass is only sufficient to grow the few plants needed about the grounds, and to furnish material for the students working in botany and horticulture.

C. B. Waldron.

BOTANICAL DEPARTMENT.

To Director J. H. Worst:

Sir: I hereby make the Seventh Annual Report of the Botanical Department of the Experiment Station. The methods of experiment are such as to extend over several years, hence the work to be reported upon this year, in principal, is not greatly different from that of the reports made in previous years. In most part the lines of work have been essentially the same. During the spring and summer of 1896 field work predominated; very extensive experiments being carried out upon the relation of cereal crops, wheat, oats and barley to the common but destructive diseases known as smuts and rusts. Some of this work was along special lines, perhaps to be described as new matters of investigation, yet the major portion of time expended has necessarily been upon the carrying out of experiments to duplicate and act as checks upon work done in previous years, and at other stations. Especially has the field tests for the prevention of smuts upon grains been done upon extensive plans. Aside from the trial of new germicides, such as formalin and various new methods of application of such substances as hot water and copper sulphate, very numerous germination tests have been made in the laboratory to test the effect of different chemicals and solutions upon the capability of the grains to germinate after treatment. This work for two months took the entire available time of Mr. Field, my laboratory assistant.

The field experiments themselves have been attempted upon a scale such as is directly applicable to the method of farming in North Dakota. Aside from more than one hundred and fifty one-tenth acre plot experiments, made in order to draw more exact comparisons as to the effectiveness of different kinds of treatment, and as to comparative yields from treatments which have previously been recognized as successful and described in early bulletins, trials have been conducted upon a field basis, treating seed at each time for a large acreage of the regular farm crop.

In the line of special experiments, an attempt was made to determine the relation of the time of seeding and the period of development of oat plants to the development of rust and smut upon the crop. It was thought that planting several varieties of seed every few days from very early in the spring until late in the summer and closely observing the development of the plants, that we might be able to decide somewhat as to such questions as the following: Does one variety smut or rust more freely than another? Do soil conditions have anything in particular to do with the appearance of smut in the crop? What relation does age of the plants have to the time of appearance of the diseases? Does smut live over in the ground so as to affect the crop the following year? and very many similar questions.

This sort of work must of necessity be continued for a number of seasons. The amount of time it takes when properly carried on is quite astonishing, inasmuch as facts of value can only be hoped to be obtained by the closest observation. It is too early to draw many definite conclusions, but I may say here that the tests show quite clearly that the old theory, that there are some varieties which are more resisting to rust than others, holds good for a few varieties, the number however is exceedingly small in which rust does not develop to some extent if atmospheric conditions are favorable. One of these resistant varieties, I think, may be named with a fair degree of firmness. It is the Early White Russian. It is, however, not rust proof. (*See p. 28.*)

As to the appearance of smut in the crop when smutty oats were used at all periods, this season's work gives no basis for statement other than that smut appeared for all dates of seeding when smutty seed was used, whether the seeding was done at an early or a late date. These matters have been reported upon in detail in a paper read before the Society for the Promotion of Agricultural Science, held at Buffalo, N. Y., Aug. 18, 1896, and are recorded in the reports of that meeting, pages 70 to 75 inclusive.

The matter of the wintering of smut of wheat will receive attention in a forthcoming bulletin, No. 27.

Following upon the work which has been recorded concerning "Conditions affecting the value of wheat for seed" and the "Rational selection of wheat for seed" as recorded in Bulletins Nos. 9 and 13 respectively of this station, the department has been attempting to carry out more definite experiments upon selection

of seeds grown upon plants which seem to belong to fixed varieties of wheat, each seed being recorded as to the plant from which it came, the part of the head, its weight taken, etc., and notes recorded as to the growth of the plants, weight, and form of each individual product, and so on. The thought in this experiment was that after carefully recorded observations should have been made for a number of consecutive years by a single person, they could be sufficiently exact and close in nature to allow of quite accurate statements concerning the question as to whether such varieties could be permanently improved, or permanently degenerated by selection when grown upon the same soil for a number of years. Aside from these general questions the side questions of physiology and heredity which would be opened up by such an investigation can scarcely be stated. This work has been conducted for two years upon two varieties, but the amount of detail involved is beyond the possibility of being carried out by a person permanently engaged in any other lines of work. Thus with some disappointment, for the above named reason, I have given up the attempt to carry this work further.

The State Flora: Each year I have reported progress in the study of the native flora of the state. Many readers of the reports are getting anxious for results in this work, not understanding the difficulties attendant upon the proper collection of the plants of the state. Necessarily this sort of work must be slow when conducted by persons whose time is much taken up by matters of instruction and experiments which are arbitrary in their demands for time. I am able to say, however, that the work is now reaching a condition in which I shall be able to report, perhaps as fast as space may be allowed for that purpose, lists of the greater groups of plants of chief interest in economic and educational matters. For example, I hope during the coming summer to finish the work of the grass survey so as to publish a complete list illustrating the range of all known species, together with a statement of the economic and educational features of the principal species.

The order of the Cruciferæ (Mustard family) will also be ready for publication. This last named group of plants contains many introduced members which in this grain growing region are pestiferous and very damaging weeds. For example there are in the order the following very bad plants: Common English Charlock, Pepper-grass, Penny-cress, Tumbling Mustard, and False Flax. It is very important that farmers should early learn to distinguish these types of plants, and their seeds. For the most important ones of such plants, it is proposed to describe carefully or illustrate exactly sufficient parts that one may learn to know the seeds, or a particular plant at sight.

This, in outline, in the method of publication which it is hoped to carry out for all of the different types of Dakota plants, so that when finished this class of reports will represent quite a perfect published catalogue of the plants of the state.

To all inhabitants of the state, excepting a possible few settlers coming from immediately adjoining states, the native plants are strangers, new in features and unknown in qualities, characteristics, and habits. The rapid upturning and constant pasturing of the virgin sod is fast destroying many of the most valuable species, and quickly eliminating many of those which are most beautiful and suited for purposes of school instruction. It seems scarcely right that we should be so thoughtless of the worth and beauty in the native plants as to allow them to disappear before they have been given a consideration.

In this western push for the development of the state's natural resources, it may be said by some that merely beautiful or educational qualities in a plant entitle it to but slight consideration. This cannot be admitted. Who may affirm how much of wealth and of general culture is due to a state's native flora? Or again, who may affirm the worthlessness or worth of great numbers of comparatively unstudied plants?

It is wished that any one who is interested in any plant or any botanical question will feel free to write to the undersigned concerning the same. In writing always state definite observations or ask clear cut questions. We are especially desirous to receive specimens of any native plants from any possible region in the state.

To make a good specimen for purposes of educational work, or to keep for reference, select a medium or small plant. If possible pull it so as to show roots, stem, leaves, flowers, and seed parts. Or better preserve plants of different ages. If a large plant, take parts of it, or if flexible bend upon itself until it may be placed upon a sheet of paper eleven by sixteen inches. To dry such a plant place it between sheets of unglazed paper, or carpet paper and keep a heavy weight upon the paper so as to press equally. Change the papers for dry ones often until the specimens are dry. They will then keep their colors best.

To those who wish to make a collection of plants, the department will send a specimen of any extra plant at hand in exchange for any properly prepared specimen sent to the college. This is a specially good opportunity for those interested in teaching botany or for persons who wish to learn concerning special plants. If one is not interested in making a collection, it is still deemed a pleasure to answer, as best we may, any questions concerning a plant which may be sent, no matter what the form in which it is sent.

In order that the teachers and others directly interested, throughout the state may the sooner get the benefit of the work being done here, it is proposed at the close of the coming summer to publish a preliminary list representing all the plants known to have been collected within the state. To this end I solicit the aid of any teachers, or other workers, who may happen to have made collections of any plants grown within the state.

TUMBLING MUSTARD.

(*Sisymbrium altissimum.*)

A mustard, new to this state, is rapidly gaining a foothold in many parts. It is properly named as above, because, when growing in a rank free condition, it breaks off at the root and tumbles before the wind. With the exception of the quality, it is not perhaps, worse than many others of the same family. It is very essential that each farmer sees to it that his own fields are kept free from these plants, and that each should persistently insist upon the same care being taken by his neighbor. No farmer can afford to sow any seed upon his land which is contaminated with mustard

FIG. I. Cross section of a rust spot upon a wheat leaf, showing the mass of fungus filaments which push up the skin covering of the leaf and develope upon their ends the red spores,(*f.*) Section magnified 400 diameters; *a*, a cell of the skin of the wheat plant; *b*, a breathing pore of the wheat plant; *c*, a group of fibrous cells of the wheat plant, the vein of the leaf cut across; *d*, one of the working cells of the leaf showing the granules of the green coloring matter not yet destroyed by the fungus.—*Bolley.*

seeds. The pods, and the four petals so placed as to form the arms of a regular cross, usually yellow or white, will serve to distinguish most mustards.

Another mustard, having a very large seeding capacity is being introduced into some parts of the state. It possesses a very long square angled pod, and thick glossy leaves, in texture like

young cabbage leaves. It is called "Hare's-ear Mustard," because its long leaves are fancied to have a form similar to the ears of that animal. The plant is known also as *Erysimum Orientale*.

As the mustards are mostly annual plants which grow from the seeds, all plants should be pulled or cut before mature, and care exercised that all seed grain is thoroughly cleaned.

THE RUSTS OF CEREAL CROPS.

Unlike smuts, the rusts of oats and wheat penetrate leaves and stems of the grain plants as they are growing in the field, and spread by means of the dusty red spores (See Fig. 1) from plant to plant. Upon damp, warm days, these spores germinate in the drops of moisture on the surface and send a fine fungus filament down into and amongst the cells of the leaf. (See Fig. II.)

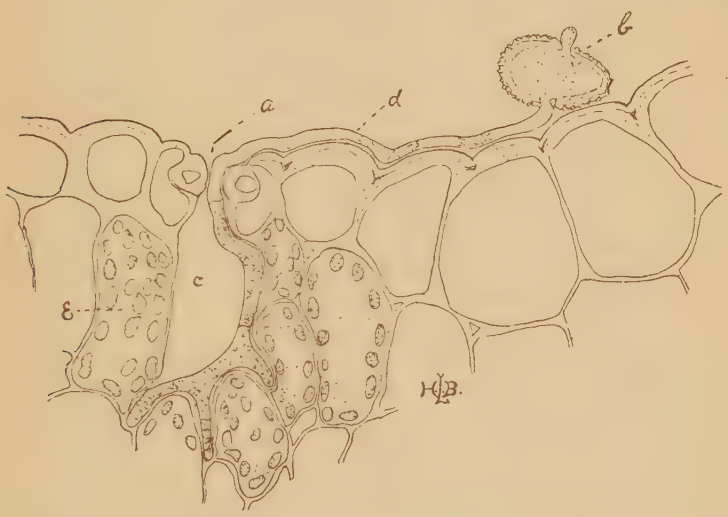

FIG. II. Part of a section through an oat leaf showing a breathing pore of the leaf into which a rust filament is inserted, the end of the germination tube seen at *b*. This illustrates how rust infection is brought about; *c*, cavity of the breathing pore of the leaf; *a*, opening to the outside. The drawing represents a magnification of 350 diameters.—*Bolley*.

This filament branches many times, each branch drawing food from its host plant, direct from the cells which it enters or lies against. After a few days, the spores begin to form under the skin cells of the leaf, finally breaking through as shown in Figs. I and III, making the rust spots which show everywhere upon the plant. The spores are then ready to be scattered by the wind. There are two kinds of spores formed during a season, the red or summer pores as seen in Fig. I and the black two-celled spores as shown in Figs. III and IV. The red ones can germinate

at once, and cause the spread of the disease from plant to plant in the field. The black ones do not germinate until the next season and hence are spoken of as "winter" or "resting spores."

VARIABLE SUSCEPTIBILITY OF DIFFERENT VARIETIES OF OATS TO ATTACKS OF RUST.

There is a prevalent belief amongst farmers that some varieties of oats are more resistant to attacks of rust than others. During the past three years quite a careful study has been made at this Station upon some thirty-nine varieties. By sowing seed of several varieties every other day from early spring to late in summer, and observing the date and force of attack, it is apparent that nearly all varieties fail to show rust spots until about one-third grown, but then will rust heavily if the air is moist and warm.

The following table shows that White Russian and Tartarian have good powers of resisting rust. Their record for 1896 is equally good.

Sample Number.	Comparative Per Cent of Rust.	
	1894.	1895.
27 Tartarian	0	1
35 Fenton's Rust Proof	5	0
30 Giant Yellow	3	15
40 Early White Russian	0	1
39 North Star	85	100
20 American White	85	95
31 Black Russian	50	100
29 Black Champion	75	75

As it seems impossible otherwise to avoid rust, oat growers may do well to give this matter of variety testing careful consideration. All those which have proved most resistant, have foliage characteristics similar to the White Russian.

POTATO DISEASES.

It is evident that the potato crop is to be one of standard value in the state. Especially is the value of this northern crop being recognized as a source of seed tubers for more southern regions. While a matter of great importance to every potato grower, I particularly wish to call the attention of special potato farmers to the importance of avoiding the introduction of potato diseases. None of the diseases are native to the state. All of the worst ones persist upon the seed, and in the soil when once introduced.

Potato Blights: These diseases for practical purposes may be

considered as essentially alike, and are comparatively new to this region. Those farmers of the valley who remember the rapid yellowing and rotting off of the vines in August of 1894, will recognize how much damage these diseases can occasion. Further, the so-called *late blight* is the common *potato rot* of older regions, and may cause entire loss of the crop when stored, by decay. These diseases persist in the ground, when once present, by means of

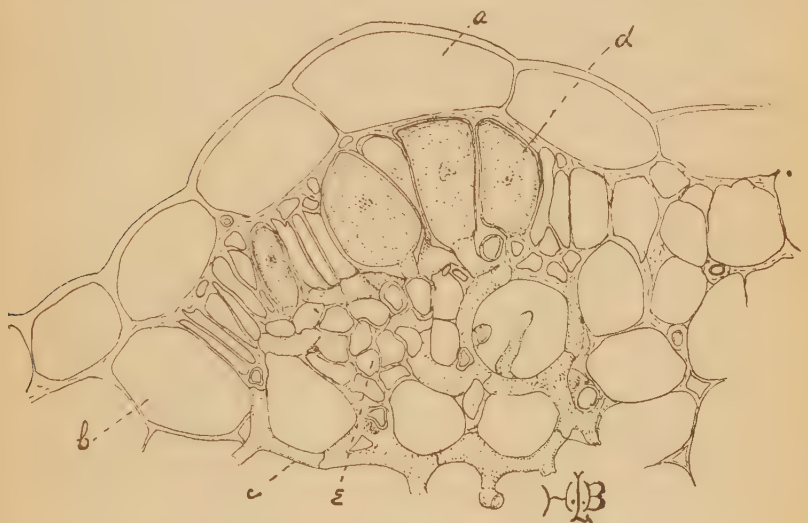

FIG. III. Part of a section of an oat leaf magnified 650 diameters showing how the fungus filaments of rust insert themselves between the living cells of the oat plant and illustrating the formation or growth of the young spores of the rust, (Winter spores); *a*, epidermal or kin covering; *b*, internal cell of the leaf; *c*, filament of fungus; *e*, some of the cells of the vein of the leaf; *d*, a young winter spore.—*Bolley*.

refuse potatoes and vines. In the growing season new vines are rapidly attacked during warm, damp days, the diseases spreading from vine to vine or field to field by the wind blown spores.

Potato Scab: The characteristics of this disease are well known. It greatly reduces the yield, occasions the setting on of many small tubers, and materially injures the selling quality.

HOW TO AVOID POTATO DISEASES.

First. Select smooth, solid seed tubers from a crop thought to be free from the diseases.

Second. To prevent scab; soak the seed tubers one and one-half hours in a water solution of corrosive sublimate, using one ounce of the chemical for every six gallons of water.

Third. To prevent blights spray the vines when about half or two-thirds grown with Bordeaux mixture, then again, ten to

fifteen days later. A third application *may* be advantageous in most seasons. Paris Green may be applied for bugs at the same time, by adding it to the Bordeaux mixture, using four ounces of Paris Green to fifty gallons of the mixture.

HOW TO MAKE BORDEAUX MIXTURE.

Copper sulphate	6 lbs
Quick lime	4 lbs
Water	50 gallons

Dissolve each chemical separately and strain before mixing. Stir thoroughly. This liquid will keep indefinitely, and is beneficial for the destruction of almost all fungous diseases. It is best applied through the aid of some sort of spray pump.

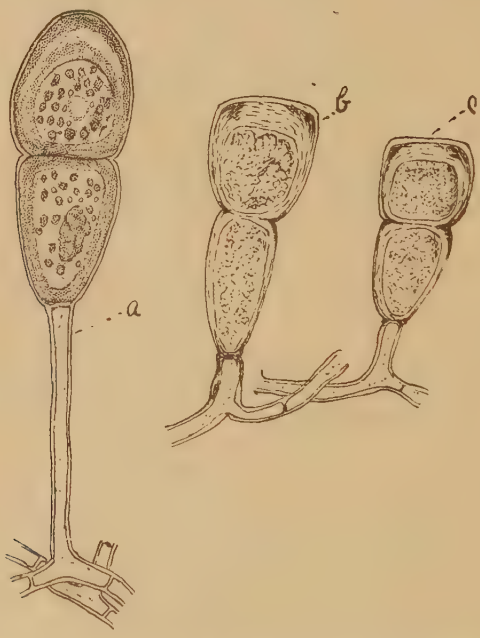

FIG. IV. Mature winter spores of two kinds of rust. *a*, of *Puccinia graminis; b* and *c* of *P rubigo-vera*. These are drawings or highly magnified spores showing the connection of the two c lled spores with the filaments which penetrate between the cells. Magnified 600 diameters.—*Bolley*.

THE EFFECTIVENESS OF CORROSIVE SUBLIMATE AGAINST POTATO SCAB UNDER ALKALINE CONDITIONS.

When lime and other alkaline engendering agents are applied to the soil as fertilizers, it has been questioned whether the corrosive

sublimate treatment for prevention of potato scab is properly effectual in preventing the growth of the scab fungus.* As the soil of this state is all practically alkaline, it seemed very proper that this should have a careful test. This has been done during the past winter in the station greenhouse. A fair number of hills were grown each from treated and untreated tubers in germ free soil. Some were left without the addition of lime, others received an abundance of it. The results point conclusively to the fact that after a proper treatment if there are no germs of the disease in the soil, the crop produced will be free from scabs regardless of alkalinity.

In previous writings I called attention to the fact that the disease germs permanently occupy old potato grounds, consequently they

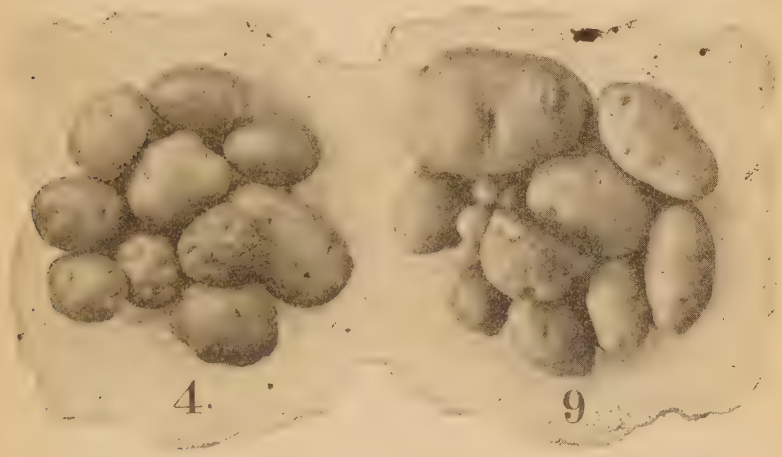

FIG. V. Cuts made from photographs of hills Nos. 4 and 9 respectively, of this experiment, showing the effectiveness of the corrosive sublimate treatment of the seed piece when the piece is finally planted in a soil impregnated with lime, and hence alkaline. In the center of each pile is seen the scabby piece from which the fair crop was raised in each case. —*Bolley.*

are subject to rapid distribution to near lying fields, especially where the soil is likely to drift, or to be carried in wash water from rains. Necessarily the treatment of seed tubers can be entirely effective only when the seed is planted upon uninfected soil. When the treatment has been properly carried out, the amount of scab which appears on the new crop may be said to be practically proportional to the number of disease germs in the soil where the tubers are finally planted. As chemically different soils and variously manured or fertilized ones influence the development and distribution of the scab plants in the soil, and inasmuch as in old potato growing districts there are many opportunities for distribu-

* Rhode Island Station Bulletin No. 33.

tion of the germ from one plot of soil to another, it is quite natural that the treatment of seed should be less effective at some stations and with some farmers than with others.

For the details concerning the past investigations upon this subject, examine bulletins Nos. 4, 9 and 19 of this station. The cut accompanying this article is made from the products of two hills, Nos. 4 and 9 respectively. In the center of each pile may be seen the old scabby piece from which, after treatment, the healthy crop was raised. In this treatment, it is very seldom that the cut piece ever decays, hence it is not strange that it may thus be photographed with the new potatoes. The soil of these two hills was thoroughly limed. It is evident that the corrosive sublimate, nevertheless, was effective. For the loan of this cut I wish here to thank the secretary of the Society for the Promotion of Agricultural Science.

Publications. No bulletin has been issued from this department since the last annual report, but manuscript is now in press for a resumé of the work of the department for three years upon the smutting of wheat, oats and barley, together with an explanation of the experiments upon the details of prevention.

Needs of the Department. Considerable new apparatus and a number of valuable reference books have been added to the facilities for investigation, but the laboratory floor space yet remains cramped. While the types of work indicated in this report have sufficed to keep myself and assistant, Mr. Field, sufficiently occupied during the time not taken by college instruction it is with some regret that I find it impossible under the present circumstances to carry on laboratory investigations of a bacteriological nature, with the degree of accuracy that is desirable, because of the fact that the present laboratories are so occupied by general work and investigations by the students. It is hoped, however, that this will be relieved in the near future in such manner as to allow the bacteriological work a separate room from the general botanical and zoological laboratories. Respectfully submitted.

Jan. 25th, 1897. H. L. Bolley.

AGRICULTURAL DEPARTMENT.

To Director J. H. Worst:

The work of this department has been chiefly along the lines already started. viz: for the improvement of grains, effect of different systems of rotation, the effect of manure upon following crops, a test of grasses, methods of seeding, nurse crops for grasses, etc. Also a study of potato varieties and methods of seeding and cultivation. A series of experiments on cultivation was begun in the fall of the past yaar. This test includes depth of plowing, depth of subsoiling, effect of packing and harrowing and the cultivation of small grain. In this experiment the effect on the percentage of soil moisture is being determined, and a thorough study made of the effect of the different methods. Work in variety tests and methods of seeding corn have been carried on.

Horse and mule feeding experiments are being carried on in much the same manner as reported in Bulletin No. 20 of this station.

VARIETIES OF WHEAT.

In 1892 this station seeded more than 132 varieties of wheat. Careful notes were made of their yield, grade, days of maturing, tendency to shell when ripe, etc., as published in previous bulletins and reports. This test of varieties has been carried on each year, a few new varieties having been added to our list, and most of the original ones dropped as their performance indicated their inferior quality for this climate.

These varieties were obtained chiefly from the northwest. A few varieties came from the South Dakota Experiment station, another list was recommended by the Ontario Agricultural College and selected from their list of tested varieties, a number were obtained from the Manitoba Experiment Farm at Brandon, Manitoba, from their tested varieties. A number of varieties came from Russia through the Minnesota Experiment Station where they have been tested a few to several years. Several varieties were obtained from farmers in Northwestern Minnesota and a large number from farmers in North Dakota, two of three making the best showing having come from the latter source. The three varieties of wheat which have given the best results in both yield and grade for five years are as follows:

BULLETIN NO. 11.

No.	Name.	Av. yield for five years. Bushels.	Grade.
66	Experiment Station Fife	22 0	1 H. 1 H. 1 H. 1 N.
20	774 Glyndon	22.0	1 H. 1 H. 1 H. 1 N.
23	Red Fife	22.2	1 H. 1 H. 1 H. 1 N.

This station and the Minnesota Experiment Station have tested many of the same varieties and have frequently exchanged seed of new varieties added to our lists. Of the seed obtained from them which has been tested for five years the following varieties have given best results:

No.	Name.	Av. yield for five years. Bushels.	Grade.
146	Bolton's Blue Stem	23.6	Average for 5 yrs. 1 N.
19	White Russian	21.4	Average for 5 yrs. 1 N.
105	711 Glyndon	21.9	Average for 5 yrs. 1 N.

The above table shows the results obtained from tests at the Minnesota Station.

Besides the varieties which have been tested for five years this Station has other varieties which have been tested for shorter oeriods of time, some of which seem more promising than the above. Improvement by selection, beginning with the selection or crossing of individual plants has given us some promising new varieties which have far surpassed their parent varieties in yield.

VARIETIES OF OATS.

Thirty varieties of oats have been grown at this Station in a variety test for four years. The five following varieties have given the best average yield.

BULLETIN NO. 11.

No.	Variety.	Per cent rust in 1894.	Per cent rust in 1895.	Average yield for four years. Bushels.
19	Black Beauty	55	90	48.40
26	Tartarian	0	1	48.40
12	Race Horse	0	15	47.48
29	Giant Yellow	65	100	44.90
2	Archangel	50	80	44.72

The percentages of rust given in the foregoing table for 1894 are notes of M. A. Carlton of the Bureau of Agriculture at Washington, D. C., and those for 1895 are the notes of Prof. H. L. Bolley of this Station. The notes in both cases were made by field inspection, and the rust on all varieties noted at one time. They were consequently not nearly uniform in ripeness, some being quite ripe, while others were comparatively green.

Unfortunately by mistake no notes on rust were made in 1896. It will be noted that two of our worst rusted varieties are among the highest yielders in the average for four years. I might also note in the same connection that their yield was good in the years when they were badly rusted.

Of eight varieties of oats grown for three years the three following have given the best yield:

Great Northern. Average yield for three years, 42.8 bushels.

American White Banner. Average yield for three years, 41.9 bushels.

Fenton's Rust Proof. Average yield for three years, 40 bushels.

Of these three varieties American White Banner rusted 60 and 70 per cent respectively in 1894 and 1895, the other two varieties being practically free from rust.

VARIETIES OF BARLEY.

This station has tested a number of varieties of barley, fifteen of which have been grown for four years. Of this number the five best yielders are as follows:

No.	Variety.	Yield 1896. Bushels.	Average yield for four years. Bushels.
7	Mansury	54.1	43.0
12	Highland Scotch	60.0	39.7
10	Highland Chief	50.8	38.0
4	Champion of Vt.	62.7	37.9
6	Chevalier	42.7	37.5

A few varieties have been tested for a shorter time, but none of them have given results which would indicate that they are superior to the best ones of the old list.

A test is in progress with grain drilled at different depths and thickness. This test is being made with wheat, oats, barley and corn. The results will be published later, as the data from one year is not considered sufficient material from which to draw conclusions.

VARIETIES OF CORN.

Thirty-seven varieties of corn have been grown at this station the past season in a variety test. There is little data to report from them, owing to the fact that the corn did not dry out sufficiently for the weights to be taken before freezing weather began.

Much attention is being given to selection and systematic crossing of different kinds, in addition to the testing of varieties. The first point worked for is to obtain an early variety. The second, to obtain a good yielding variety. The third point is to raise the height of the ears of early ripening, good yielding varieties.

The varieties noted in bulletin 23 of this station reached the stage of maturity given in the following table in 1896.

Number.	NAME.	Av. Yield of Grain '94 and '95.	Stage of Maturity at Frost.			Yield Fodder Per Acre 1895.
			1894.	1895.	1896.	
4	Mercer Flint..	37½ Bu.	Ripe	Ripe	Ripe	2.33 Tons.
8	Minnesota Flint.....	34¾ Bu.	Ripe .	Ripe	Ripe	1.80 Tons.
2	New York Flint Dent.....	33¼ Bu.	Dough	Ripe	Dough	2.87 Tons.
16	Hoag's Yellow Dent.....	33¼ Bu.	Dough	Ripe	Dough	1.70 Tons.
9	Golden Canadian Y. Dent.	33½ Bu.	Dough	Dough	Dough	3 15 Tons.
3	Earliest Canadian Dent...	32 Bu.	Dough	Dough	Ripe	2.30 Tons.

The varieties were planted May 22d, 1895 and June 1st, 1896. The notes for 1896 were made Sept. 19th, the frost occurring the previous night.

Of the varieties tested in 1896 not grown at this station prior to that time, Boley's Improved Rea, Adam's Extra Early and King Phillip ripened. Adam's Extra Early is a white dent corn, well known in the Eastern and Middle States. The other varieties are flint corn, Boley's Rea a white flint, and King Phillip a bronze-colored flint. There is much prejudice among North Dakota farmers in favor of dent corn. I do not think this prejudice has a foundation in fact. I regard flint corn of as much value per bushel for feed as dent corn, and the flint varieties usually ripen earlier and seem better adapted to northern climatic conditions than dent varieties.

KAFFIR CORN.

Red Kaffir Corn, White Kaffir Corn, Millo Maize, Durra and Jerusalem Corn have all been grown at this station during the past three years. These plants are similar in their general form of growth, all being non-saccharine sorghum. The grain is formed in the head, as it is in sorghum. Red Kaffir Corn has shown the best results at other State Experiment Stations in point of yield.

They have all failed to ripen on the station grounds for the past three years. They form a very leafy fodder of a poorer grade than that from Indian Corn. The Kansas Experiment Station reports it to be excellent to withstand drouth, and speaks of it as a good fodder and grain producer in that state. It is possible that on the lighter soils in the southern part of this state it might ripen in the longest seasons. It is too late in maturing to become a competitor of Indian Corn. It is a waste of time and money to try to grow Kaffir Corn while good results from Indian Corn are certain.

Teosinte grown at this station the past season gave no promise of proving a valuable forage plant.

DWARF ESSEX RAPE.

Dwarf Essex Rape has been grown at this station for the past four years, making a good crop each year. In 1892 rape cut and weighed green produced 11,000 pounds, or five and a half tons, per acre. In 1895 the crop was cut, and weighed green 13,000 pounds per acre, or six and a half tons. In 1896 it produced 27,931 pounds of green matter per acre, or nearly fourteen tons. A small portion of this was dried by artificial heat until as dry as well dried hay, in which condition it weighed 3,275 pounds, or nearly one and three-fourths tons per acre. The crop was planted June 30th and harvested September 19th. It was fit for pasture August 20th. The usual way of utilizing a crop of rape is to pasture it off with sheep. It is highly prized in Canada, and in the older portions of the United States as a fattening feed for sheep. It can be sown broadcast at the rate of five pounds per acre, or in drills thirty inches apart at the rate of three pounds per acre. When sown in drills it is cultivated until ready to pasture, or until the leaves nearly cover the ground. The seed resembles turnip seed, and should be planted one and a half to two inches deep. It is not adapted for feeding milch cows, as it is apt to taint the milk.

Especial care should be exercised when sheep are first placed in a rape field, as they are likely to overeat, causing hoven or bloat. In this way rape is much worse than clover, the effects of which are quite generally known. After they have become accustomed to it, however, as in the case of clover, no damaging effects are noted. Crops of wheat following rape show a remarkable increase over crops which have had wheat continuously. In 1895 a portion of a field which had grown rape in 1894 yielded 37⅓ bushels of wheat per acre, while another portion adjoining it, which had grown spring rye in 1894, produced only 17½ bushels per acre. The two portions of land had been cropped in the same way prior to that time. In 1895 wheat on land which had produced rape the previous year yielded at the rate of 19.6 bushels per acre, while four adjoining plots on land summer fallowed the previous year yielded 15.4 bushels per acre, and six plots which had produced wheat before, averaged 9.4 bushels per acre. In all these tests

the rape was planted in drills and cultivated. The rape was not pastured, but cut off in each of the above tests which did not give the land the advantage which would come from the droppings of sheep.

GRASSES.

Austrian Brome Grass (*Bromus inermis*) is the only new variety of grass which promises to be of particular value in this state. It is an early variety, very hardy, and is not easily injured by frost. It reaches a height of two and a half to four feet, is very leafy and forms a very compact sod. The head is branched, resembling blue grass somewhat, though much heavier and coarser in head and seed than blue grass. It is a perennial grass and promises well for pasture. Seed it at the rate of twenty pounds per acre without a nurse crop. It is a grass which does not do well with a nurse crop of any kind. Seed it in an ordinary grain drill as early in the spring as your land is in good condition. Keep the weeds down by mowing once or twice during the first season, setting the sickle bar high. It has been growing on the Station grounds for six seasons in small plats, and has been sown on a field scale for two seasons. It stands drought exceptionally well. The writer saw it growing at Brandon, Manitoba and at Indian Head, Assiniaboie, in the Dominion of Canada last July, on high dry ridges in a climate where the rainfall is eight to ten inches which is less than the total rain and snowfall in the western part of North Dakota. These fields were of old sod (more than a year) and produced from two to three tons of hay per acre. Their experimental station workers consider it too dry in their climate to attempt to grow Timothy or clover.

Austrian Brome Grass has been tried in small plots in several portions of this state, and is making an excellent showing.

Timothy and red clover has been grown on the Station grounds and on the college fields each year since 1893. About fifty acres of land was growing Timothy and red clover mixed at that time, which had been sown some time previous. Fifteen acres of this amount has been kept for hay and has given an average yield of about one and a fourth tons per acre. After four years it has become somewhat weedy and will be plowed up next season. The remaining portion has been used for pasture, and has been eaten off very close with cattle and sheep for the past three seasons, and has stood the treatment without much apparent injury. In the spring of 1894 an eighty-acre field on the farm was sown to grass with oats as a nurse crop. The oats was seeded with a drill and the grass afterward with a wheelbarrow seeder, which was followed by a peg-toothed harrow. The oat crop was heavy, and the grass made about half a stand.

In the spring of 1895 another eighty-acre field was seeded to grass, with wheat as a nurse crop. The wheat was sown with grain drills north and south, and the grass seed with a grain drill

running east and west after the wheat had been sown. The drill was allowed to run very shallow while seeding the grass—an inch and a half to two inches deep. To regulate the rate of seeding common barrel salt was used and proved very satisfactory. The mixture as sown was eight pounds of Timothy seed, five pounds red clover seed, and four pounds of salt per acre. After a short time the grass plants appeared in the cross drills in such a thrifty growth that the drill row could be traced by the eye at some distance. The growth of wheat was heavy, over twenty bushels per acre of No. 1 hard, and the stand of grass was excellent. This eighty-acre field produced an average of about a ton and a quarter of hay per acre in 1896, the first season after seeding, and without losing a crop on the land. In 1896 a twenty-acre field was seeded to barley and cross seeded with Timothy, red clover and barrel salt as described above. The grass came on well and went into winter with every indication of being a good stand.

The nurse crops used in the above cases were taken by force of circumstances, rather than from any special choice on my part.

Clover. In 1895 a piece of land containing about twenty acres, which is reserved for a future portion of the college campus, was seeded to wheat and cross drilled with Timothy, red clover and salt as described above, except that a larger proportion of clover seed was added and a proportionate decrease of Timothy seed was made. The mixture consisted of about ten pounds of clover seed, four pounds of Timothy and four pounds of common barrel salt per acre. The illustration from a photograph on page — of this report will give the reader a very good idea of the enormous growth which the clover made. This land had been manured with stable manure free from litter, the previous year, by the Horticultural Department, which was in charge of the land at that time.

In 1896 a plot of two acres was seeded to red clover without a nurse crop, by means of a grain drill, and an excellent stand resulted. In 1895 three half-acre plots were sown to spring rye and a test of red mammoth and alsike clover begun. The clover seed was sown in the drill mixed with rye as a nurse crop. The stand of alsike clover was poor, and that of red and mammoth only fair. Their yields in 1896 were as follows:

Alsike clover	1629	pounds	cured	hay per acre.
Mammoth clover	2270	"	"	"
Red clover	2275	"	"	"

The experiment was repeated in 1896 by sowing additional plots, and will be carried on for several years.

ROTATION OF CROPS.

A rotation experiment was started by this station in 1892 upon forty acres of land which had produced wheat continuously for a number of years. It was in a very uniform condition at that time, as shown by chemical analysis and inspection. The plots were an

acre in size, two rods wide by eighty rods long, with twelve-foot alleyways between. In 1894 the plots were cut down to one-third acre in size and six additional plots made of a portion of the part which was cut off from certain of the original ones.

The following table gives the plan of the experiment and the results in detail:

	Yield in Bushels Per Acre.			
	1893	1894	1895	1896
Wheat continuously, average for six plots	9.4	19.6	23.3	16.0
First, second and third wheat crops after barren fallow, average for four plots	15.3	24	24.9	.....
First, second and third wheat crops after cultivated crops, corn, peas, rape and mangels, average for six plots	16.5	24.8	23.3	.....
First second and third crops of wheat after millet, one plot	13.3	23.8	23	.....
First crop of wheat after timothy and clover for two years, one plot	.....	.....	31	20 5
First crop of wheat after flax for one year, average for two plots	.....	.....	23.3	.....
Second crop of wheat after flax for one year, one plot	.....	.....	.....	19.2
Flax continuously for three years, one plot	.....	9.5	12.6	12.6
First and second wheat crops after flax and fallow, one plot	.....	14.5	25	.....
First, second and third whe t crops after field peas, one plot	14.4	23.5	23	.....
First, second and third wheat crops after green manuring with field peas, one plot	10.4	23.5	23	.....
First, second and third crops of wheat after green manuring with millet, one plot	14.1	22.8	23.5	.....

From rotation of wheat with spring rye, barley and oats it will be seen by plots 21, 22 and 23 in the above table that little difference is shown in the wheat crops following from those where wheat follows wheat continuously.

Stating the above results in per cent, using the yield on the wheat continuously plots as a basis, gives the following:

Wheat after summer fallow, 63 per cent greater yield the first year, 22½ per cent greater yield the second year, with no increase the third year. Wheat after cultivated crops gave 75½ per cent greater yield the first year, 26½ per cent more the second year, with no difference the third year.

Wheat after millet yielded 41½ per cent more the first year; 21½ per cent better the second year with no difference the third year.

First crop of wheat after timothy and clover, gave a yield 33 per cent greater than the continuous wheat plots, and 25⅓ per cent better yield the second year.

Flax grown for one year on plot 31 showed no appreciable effect on the following wheat crop.

Flax grown continuously for three years on plot 30 has shown no bad effect in any way.

Wheat after field peas gave 53 per cent greater yield the first year, 20 per cent increase for the second year, and little difference the third year when compared with the wheat after wheat plots.

The plots green manured with the peas and millet average 31 per cent increase in the first following wheat crop, 18½ per cent in the second, and little difference in the third year's crop as compared with the wheat after wheat plots.

A lesson on manuring land can also be drawn from the results. In 1892 and in 1896 plots six and ten were manured at the rate of six loads of well rotted stable manure per acre. Plots five and six were cropped alike, and plots nine and ten produced the same kinds of crops, and so will serve as check plots. The following is the result:

YIELD OF WHEAT AFTER CORN MANURED.

	1893.	1894.	1895.	1896.
Plot 5 not manured—yield per acre...	14.4	25.00	24.00	.....
Plot 6 manured—yield per acre.....	17.2	24.75	25.00	.....
Difference.....	2.8	0.25	1.00	.....
Plot 9 not manured—yield per acre ..	13.3	23.66	23.00	2895 pounds hay
Plot 10 manured—yield per acre.....	15.1	25.33	23.00	3765 pounds hay
Difference.....	1 8	1.66	....	870 pounds hay

The results show a decided increase in yield resulting from the manure. Much of the trouble that has come from manuring land, which has caused many farmers in this state to condemn it, has probably come from not having the manure well rotted. Strawy, littery manure, tends to make the land droughty, by making it lie up too loose, and by failing to rot for some time.

During the season of 1896 I was assisted by R. W. Clark, of St. Anthony Park, Minn., who took charge of the greater part of the field work and carried out the details in a very creditable manner.

J. H. SHEPPERD.

DAIRY DEPARTMENT.

To Director J. H. Worst:

The creamery in connection with the College and Station was in operation throughout the year receiving 108,373 pounds of milk containing 4,077.6 pounds of fat; and 57,229 pounds of cream containing 11,223.6 pounds of fat making a total of 15,234.2 pounds of butter received during the twelve months, and for which was paid the sum of $2,500.99. The milk was furnished by farmers contiguous to the creamery, and the herd belonging to the experiment station, while the larger part of the cream came from Tower City, and Glyndon, Minn.

The supply was very irregular so it was not deemed advisable to attempt any experimental work in butter and cheese making.

The department has received a number of communications the past season from dairymen and creamerymen asking how to remove the flavors in milk, caused by the cows eating wild onions and similar weeds. Experimenters have not been very successful in removal of such flavors, so but little advice could be given them. It is hoped that by the end of another season some experiment work of this nature can have been undertaken with decidedly beneficial results. The importance of such work is readily seen when we consider that in a large part of the state the flavor of our butter depreciates the price one or two cents a pound, and extends over a period of from four to eight weeks.

The Station herd consisting of native stock entirely, has been thoroughly tested, and cows that would not produce upwards of two hundred pounds per annum sold to the butcher.

A pure bred registered Jersey bull, that is a grandson of "Dear Keepsake," being a daughter of the great Combination bull, has recently been purchased from F. H. Merrell, of Portage, Wis. This bull will be bred to the station cows with the view of producing a dairy herd of a pronounced dairy type and special butter producing qualities.

There are undoubtedly many good milch cows among the native cows of the state, which by a judicious system of selecting and breeding to pure bred sires of special dairy breeding would become the foundation of some excellent herds of dairy cows.

E. E. KAUFMAN.

DOMESTIC SCIENCE DEPARTMENT.

To Director J. H. Worst:

It is but necessary to observe in the homes of all classes that good bread is the exception and poor bread the rule. When we realize that good bread is one of the most nutritious and inexpensive foods, and without doubt the most important, it seems right that more thought and attention should be given the subject of bread making. The process is not hard when the principles that govern it are well understood and attention is given to details.

Good yeast and flour are necessary to produce perfect bread. While the best flour is to be preferred, it is by no means essential that the highest grade be used, for light, wholesome bread of good flavor, though having a darker color, can be produced from second and third grade flours. So by practicing close observation and using judgment, good satisfying bread can be made by those who cannot use patent flour.

By strength of flour is meant the measure of its power to absorb or combine with water. Therefore, the best flour—that one richest in gluten—will require the least amount of flour to produce the proper consistency when added to a given quantity of water. In using poor flour which is deficient in gluten it is necessary to use a greater amount to a given quantity of water. Spring wheat, which is used exclusively in this state, has a harder grain than winter wheat flour, and produces a harder, stronger flour, which is capable of absorbing more water and is considered easier to handle than flour made from winter wheat. Good strong yeast is necessary for good results in bread making. Pure yeast gives sweet, well flavored bread; while putrefactive ferments produce coarse, rough or sour loaves. Compressed yeast is without doubt the best ferment known for bread making and is certainly the most convenient and economical when time and results are considered. But in many places it is impossible to obtain compressed yeast, and it has been found very convenient and satisfactory to use the home made yeast.

The amount of flour necessary to be mixed with a given quantity of wetting to make dough of the proper consistency varies with the flour and the wetting. The stronger the flour, the less it requires; and if milk, or milk and water be used, less will be required than if water alone is used.

The quantity of yeast is also very important, for if too little be used fermentation will be retarded and the rich, nutty flavor will be lost. The method of adding shortening and sugar to bread

is preferred by some. Shortening interferes somewhat with the proper action of the yeast. If sugar is added, one level tablespoon to a pint of water is about enough to restore the natural sweetness lost by fermentation.

Home made yeast made according to the following gives very satisfactory results. One-fourth cup sugar, one-fourth cup flour, one tablespoon salt. Grate on this three large raw potatoes, stir together. Then add one quart boiling water and beat well. It should form a thick starch paste. If it does not thicken on addition of the water, heat in a double boiler. One cake dry yeast, or one-half cake compressed yeast, dissolved in a half cup tepid water, should be added when the paste has cooled to lukewarm throughout.

For the bread, take one pint lukewarm water, one-half cup yeast, one tablespoon butter, one teaspoon salt; between two and a half and three pints of flour. The sugar and butter need not be added. Allow salt, butter and sugar to dissolve in water. Add the yeast and then beat in the flour gradually. When the mass becomes stiff enough, remove from the bowl and knead, adding sufficient flour to keep it from sticking to the board. When smooth and elastic, brush with melted butter, and put to rise at 75 degrees Fahr. Allow it to double its size, then knead again. Let it rise once more until twice its original size, then shape into loaves. When the loaves have doubled in size, bake at 375 degrees Fahr. for about forty-five minutes.

The following shows experiments in which home made yeast was used with three different brands of patent flour.

No.	Weight in Grams.							
	Flour.	Water.	Sugar.	Salt.	Butter.	Yeast.	Dough.	Bread.
1	424	217	9	4	8	105	694	617
2	437	217	9	4	8	105	711	633
3	449	217	9	4	8	105	710	621

The following method of making bread was used in the experiments below recorded with the amount of flour varying according to the grade. One-half pint of milk scalded and cooled, one-half pint lukewarm water, one teaspoonful salt, one cake compressed yeast (one-half ounce) dissolved in a third cup cold water. Add flour to this until a dough is formed that is stiff enough to be turned from the mixing bowl. Knead, adding flour until it ceases to stick. This amount varies usually, between two and a half and three pints. Put in a well greased bowl, brush the surface lightly with melted butter to prevent crusting. Cover well and set to rise in a temperature of 75 degrees for about three hours. It may now be made into loaves or rolls, but is improved if kneaded down and

allowed to rise again for about one hour. The dough should be double the size it was when set to rise. The oven should be hot enough to brown one teaspoonful of flour in two minutes, or about 375 degrees Fahr., when the bread is put into it. An ordinary sized loaf will require about forty-five minutes for baking. The bread when baked should be of a rich brown color all over. When cut it should be of fine even texture throughout, the holes should be small and even, and the color as white as the grade of flour will allow.

The following table shows the minimum, maximum and average amounts of flour of a certain grade used in a number of experimental tests to determine the variation in the amount of flour, all other conditions being equal.

No.	Weight in Grams.							
	Flour.	Water.	Milk.	Butter.	Salt.	Yeast.	Dough	Bread.
	Minimum 307	142	116	3	5	6	523	436
1	Maximum 370	142	116	3	5	6	590	536
	Average 338½	142	116	3	5	6	556½	486
	Minimum 317	142	116	3	5	6	560	518
2	Maximum 381	142	116	3	5	6	535	466
	Average 349	142	116	3	5	6	547½	492
	Minimum 356	142	116	3	5	6	598	512
3	Maximum 374	142	116	3	5	6	613	551
	Average 365	142	116	3	5	6	605½	531
	Minimum 363	142	116	3	5	6	587	533
4	Maximum 396	142	116	3	5	6	635	575
	Average 379½	142	116	3	5	6	611	554
5	Average 386	142	116	3	5	6	591	543
6	Average 415	142	116	3	5	6	616	569
7	Average 480	142	116	3	5	6	578	542

Nos. 5, 6 and 7 represent the three grades of flour from one mill, and while they showed conclusively that good bread can be made from all grades, yet the difference in the amount of flour used is very noticeable. MARIE B. SENN.

In conclusion I wish to emphasize the fact that the station is managed in strict harmony with the law creating it, and for the purpose of benefiting the farmers of the state. No reliable data can be secured from experiments or investigations until they have been pursued for several years, which accounts for the fact that the influence of the station has not been felt more in the past. The climatic and soil conditions of North Dakota are peculiar, and

the seasons so short that no country in the world of equal fertility requires so much study to master its agricultural resources. In no country is it more essential that the farmer so understand the laws that control plant growth that not a day may be lost, for there is not a day to waste.

The desirability of farming as an occupation depends upon the average success that is assured, and success comes just in proportion as agriculture obeys science. It is particularly desirable that the farmers of the state, whenever convenient, visit the station and see the work performed and the methods employed. June is perhaps the most interesting month of the year for this purpose, and we hope to arrange for a general excursion to the Experiment Station next summer.

J. H. Worst,
Director.

STATEMENT

Government Agricultural Experiment Station for North Dakota, in account with the United State appropriation, 1895–6.

DR.

To receipts from Treasurer of the United States per appropriation for fiscal year ending June 30, 1896, per act of Congress, approved March 2, 1887	$15,000 00

CR.

By salaries	$ 4,300	83
Labor	5,676	86
Publications	423	40
Postage and stationery	261	38
Freight and express	287	22
Heat, light and water	487	93
Chemical supplies	45	15
Seeds, plants and sundry supplies	817	25
Feeding stuffs	495	88
Library	9	15
Tools, implements and machinery	736	42
Furniture and fixtures	212	14
Live stock	373	00
Traveling expenses	18	50
Contingent expense	104	24
Buildings and repairs	750	00
Total	$15,000	00

SUPPLEMENTARY STATEMENT.

DR.

To receipts from state for year ending June 30, 1896	$	83 34
From station and farm proceeds of sales	2,386	46
Total	$ 2,469	80

CR.

By labor	$	943 25
Freight and express		7 89
Heat, light and water		114 14
Seeds, plants and sundry supplies		619 38
Feeding stuffs		42 61
Furniture and fixtures		171 76
Live stock		27 50
Traveling expenses		82 80
Contingent expenses		49 49
Building and repairs		410 98
Total	$ 2,469	80

The above statement is a correct account of government and state appropriation for the fiscal year ending June 30, 1896.

P. W. FARNHAM, Secretary.

TABLE SHOWING PLAN OF ROTATION

Plot.	1883 to 1891	1892	1893	1894	1895	1896
1 yield.	wheat	wheat 21.5 bu	wheat 8.2 bu.	wh at 20 bu	wheat 24 bu	wheat 16 1-7 bu
2 yield.	wheat	wheat 19.3 bu	wheat 10 bu	wheat 21¾ bu	wheat 23 bu	wheat 17.9 bu
*3 yield.	wheat	wheat 21.1 bu	timothy 2,097 lbs	timothy 2,400 lbs	wheat	wheat .....
4 yield.	wheat	fallow *a*	wheat 11.8 bu	wheat 23¾ bu	wheat 23½ bu	fallow *a* .....
5 yield.	wheat	corn 33 bu 1,850 lbs fod	wheat 14.4 bu	wheat 25 bu	wheat 24 bu	corn .....
6 yield.	wheat	corn *b* 37.5 bu 2,000 lbs fod	wheat 17.2 bu	wheat 24¾ bu	wheat 25 bu	corn *b* .....
7 yield.	wheat	field peas 10.5 bu	wheat 14.4 bu	wheat 23½ bu	wheat 23 bu	field peas 24¾ bu
8 yield.	wheat	g. manure *c*	wheat 10.4 bu	wheat 21⅔ bu	wheat 23 bu	g. manure *c* .....
9 yield.	wheat	millet 3,950 lbs	wheat 13.3 bu	wheat 23⅔ bu	wheat 23 bu	millet 2,895 lbs
10 yield.	wheat	millet *b* 4, 00 lbs	wheat 15.1 bu	wheat 25½ bu	wheat 23 bu	millet *b* 3,765 lbs
11 yield.	wheat	g. manure *d*	wheat 14.1 bu	wheat 22¾ bu	wheat 23½ bu	g. manure *d* .....
12 yield.	wheat	rape 11,000 lbs	wheat 19.6 bu	wheat 26¼ bu	wheat 26 bu	rape 27,931 lbs gr'n 3,273.5 lbs dry
13 yield.	wheat	mangels 15,000 lbs	wheat 18.5 bu	wheat 26½ bu	wheat 20½ bu	mangels .....
14 yield.	wheat	wheat 21.1 bu	wheat 8.1 bu	wheat 20¼ bu	wheat 22½ bu	wheat 15 5-6 bu
15 yield.	wheat	fallow *e*	wheat 16 bu	wheat 25¾ bu	wheat 24½ bu	fallow *e* .....
16 yield.	wheat	wheat 19.6 bu	tim & clover 2,070 lbs	meadow 3,225 lbs	wheat 31 bu	wheat 20½ bu
*17 yield.	wheat	†wheat 19.6 bu	clover 1.715 lbs	†wheat 20⅔ bu	fallow	wheat .....
18 yield.	wheat	peas 8 6 bu	wheat 12.9 bu	clover 3,000 lbs	fallow	wheat .....
19 yield.	wheat	wheat 20 bu	wheat 11.8 bu	wheat 22⅝ bu	wheat 24½ bu	wheat 16.4 bu
20 yield.	wheat	fallow	wheat 19.6 bu	wheat 25⅝ bu	wheat 25 bu	potatoes .....
21 yield.	wheat	spring rye 13.2 bu	wheat 10.6 bu	wheat 18½ bu	spring rye	wheat 20.1 bu
22 yield.	wheat	barley 29 bu	wheat 6.4 bu	wheat 18½ bu	barley 13 bu	wheat 16½ bu
23 yield.	wheat	oats 75 bu	wheat 10.1 bu	wheat 18 bu	oats 41½ bu	wheat 14.9 bu

EXPERIMENTS AND RESULTS.

1897	1898	1899	1900	
wheat	wheat	wheat	wheat	Wheat continuously, fall plow last of September.
wheat	wheat	wheat	wheat	Wheat continuously, fall plow very late.
wheat	wheat	timothy	timothy	Wheat four years; timothy two years, sod plowed in August.
wheat	wheat	wheat	fallow *a*	Wheat three years. fallow one year, manure *b*; (plow twice.)
wheat	wheat	wheat	corn	Wheat three years, corn one year.
wheat	wheat	wheat	corn *b*	Wheat three years, corn (manured *b*) one year.
wheat	wheat	wheat	field peas	Wheat three years, field peas one year.
wheat	wheat	wheat	g. manure *c*	Wheat three years, green manure with peas one year.
wheat	wheat	wheat	millet	Wheat three years, millet one year.
wheat	wheat	wheat	millet *b*	Wheat three years, millet (manured *b*) one year.
wheat	wheat	wheat	g. manure *d*	Wheat three years, green manured one year.
wheat	wheat	wheat	rape	Wheat three years, rape one year.
wheat	wheat	wheat	mangels	Wheat three years, mangels one year.
wheat	wheat	wheat	wheat	Wheat continuously, fall plow, last of Sept.
wheat	wheat	wheat	fallow *e*	Wheat three years, fallow one year; (plow once.)
barley	wheat	tim & clover	meadow	Wheat one year, meadow two years, wheat two years, barley one year.
barley	wheat	clover	clover	Wheat one year, clover two years, wheat two years, barley one year.
wheat	wheat	peas	wheat	Wheat three years, peas one year, wheat one year, clover two years.
wheat	wheat	wheat	wheat	Wheat continuously, clover in wheat annually.
wheat	wheat	wheat	potatoes	Wheat three years, potatoes one year, (level ground in fall.)
wheat	spring rye	wheat	wheat	Wheat two years, rye one year, plow before wheat harvest when in rye.
wheat	barley	wheat	wheat	Wheat two years, barley one yr, plow before wheat harvest when in barley.
wheat	oats	wheat	wheat	Wheat two years, oats one year.

TABLE SHOWING PLAN OF ROTATION

Plot.	1883 to 1891	1892	1893	1894	1895	1896
24 yield	wheat	wheat 19.4 bu	wheat 8.6 bu	wheat 18⅓ bu	wheat 23½ bu	wheat 19.05 bu
25 yield	wheat	wheat 17.3 bu	wheat 9.5 bu	wheat 15½ bu	wheat 23 bu	wheat 11.45 bu
*26 yield	wheat	fallow	wheat 14.1 bu	wheat 21 bu	wheat	fallow
*27 yield	wheat	wheat 17.3 bu	timothy 2,020 lbs	timothy 2,613 lbs	wheat	wheat
*28 yield	wheat	wheat 13.3 bu	timothy 1,888 lbs	timothy 3,225 lbs	timothy	wheat
29 yield	wheat	flax not threshed	fallow	wheat 14½ bu	wheat 25 bu	flax 8.4 bu
30 yield	wheat	wheat 19.4 bu	wheat 8.6 bu	flax 9½ bu	flax 12⅝ bu	flax 12.6 bu
31 yield	wheat	wheat 17.3 bu	wheat 9.5 bu	flax 8½ bu	wheat 13½ bu	flax 10.5 bu
32 yield	wh at	fallow	wheat 14.1 bu	timothy 2,805 lbs	wheat 17 bu	fallow
33 yield	wheat	wheat 17.3 bu	timothy 2,020 lbs	flax 10½ bu	wheat 23 bu	wheat 19.15 bu
34 yield	wheat	wheat 13.3 bu	timothy 1,888 lbs	wheat 24⅝ bu	wheat 22½ bu	flax 13.4 bu
35 yield	wheat	flax not threshed	fallow	wheat 25⅓ bu	flax 8½ bu	corn

† Clover seed mixed with wheat when seeded.
a Plow twice.
b Six loads rotten manure per acre.
c With field peas.
d With millet.
e Plow once.
* Thrown out in 1895 by reason of dust having drifted over the plot.

EXPERIMENTS AND RESULTS—*Continued.*

1897	1898	1899	1900	
wheat	wheat	wheat	wheat	Wheat continuously, spring plow.
wheat	wheat	wheat	wheat	Wheat continuously, fall plow, last of Sept.
wheat	wheat	wheat	fallow	Wheat three yrs., fallow one yr., plow July and Oct. when fallow.
wheat	timothy	timothy	wheat	Wheat three years, timothy two years, plow sod in Aug.
wheat	wheat	wheat	timothy	Wheat four years, timothy three years, plow sod in Aug.
fallow	wheat	wheat	flax	Wheat two yrs., flax one yr., fallow one yr., plow fallow July and Oct.
flax	flax	flax	flax	Flax continuously (after 1893).
wheat	flax	wheat	flax	Wheat one year, flax one year (after 1894).
flax	wheat	wheat	fallow	Beginning 1895 wheat two years, fallow one year, flax one year.
flax	wheat	wheat	flax	Wheat two years, flax one year, (beginning 1894).
corn	wheat	wheat	flax	Beginning with 1894 wheat two years, flax one year, corn one year.
wheat	flax	corn	wheat	Wheat one year, flax one year, corn one year (beginning 1894).